



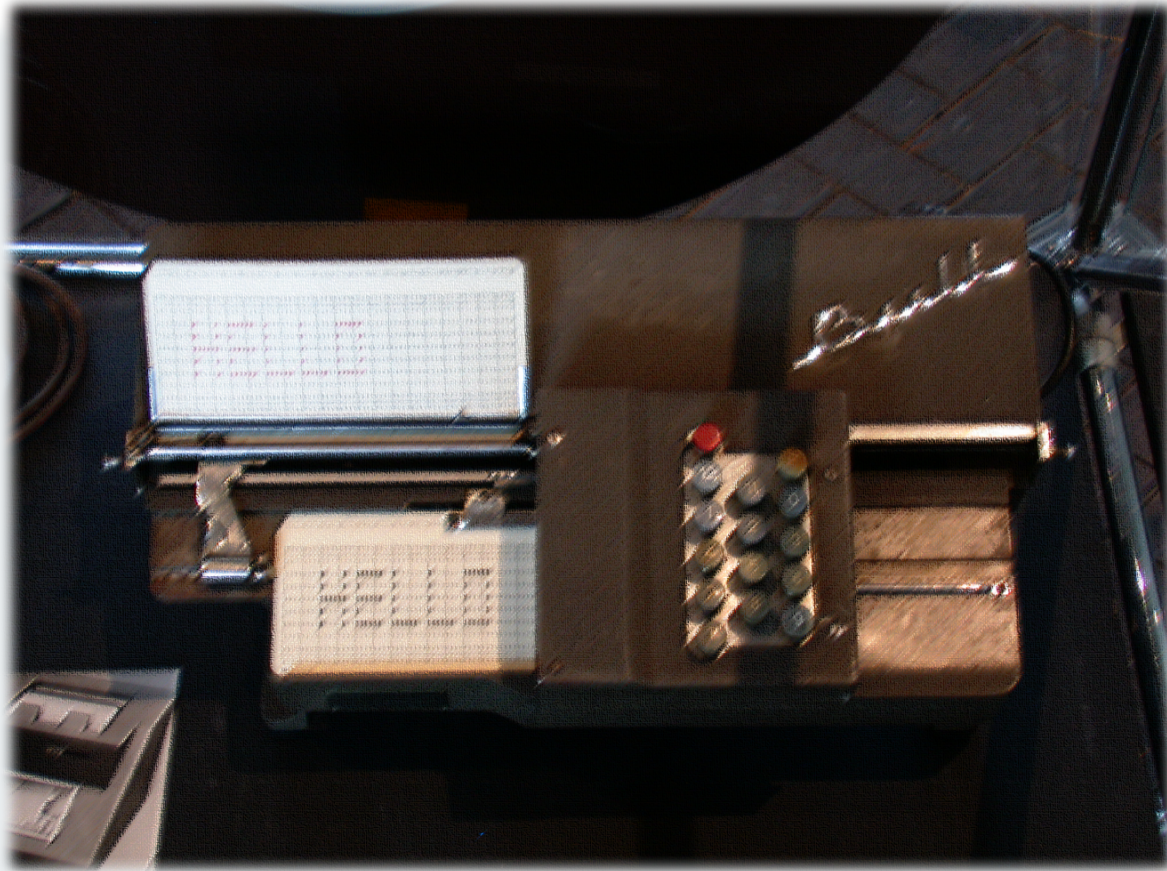
# **Architecture for Cognitive Networking within NASA's Future Space Communications Infrastructure**

**Presented By: Gilbert Clark / MTI Systems**

## **Authors**

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# Presenter Biography





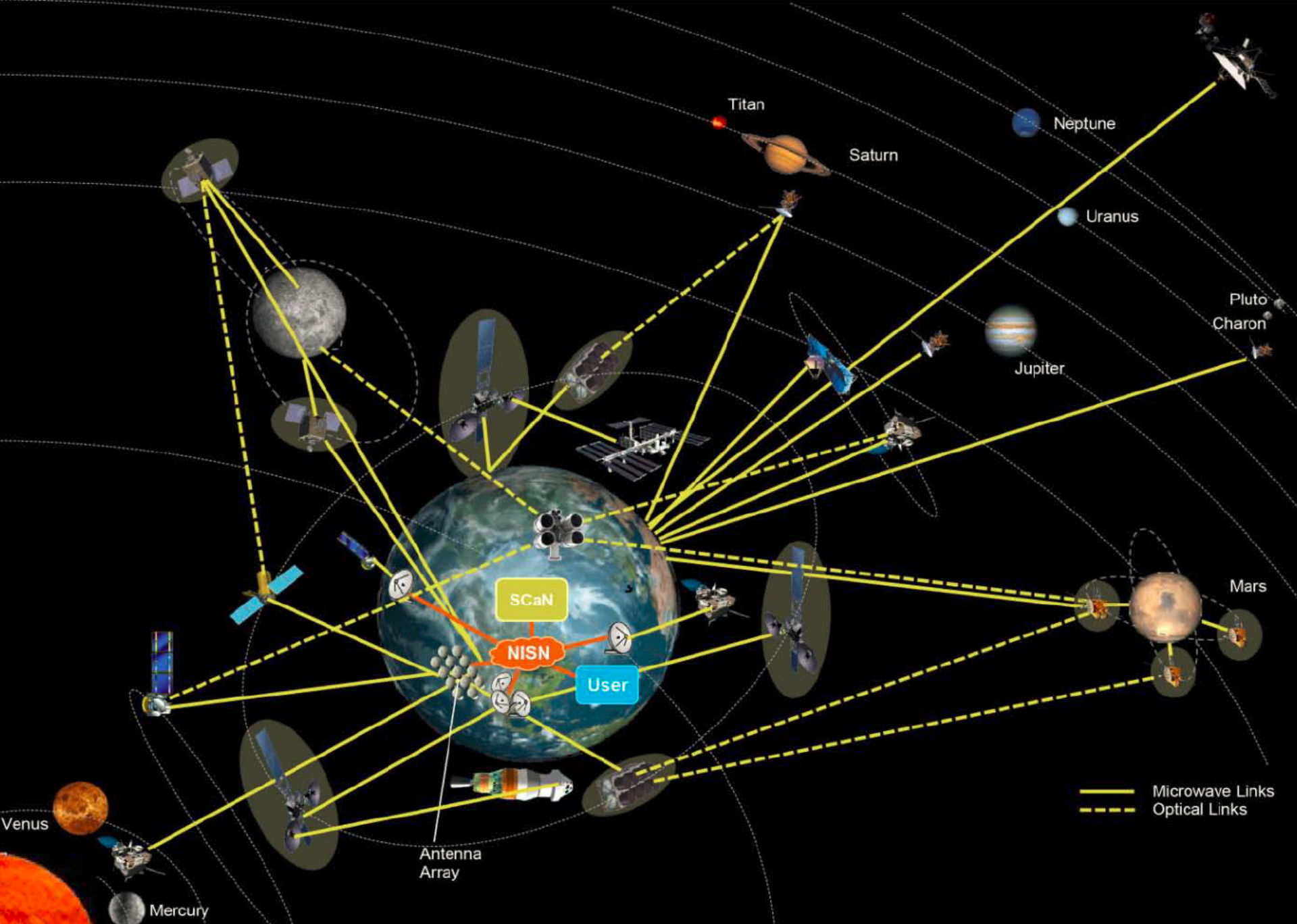
## Agenda

- Discuss cognitive and possible roles in future SCaN
- Discuss architecture concepts
  - What might cognitive look like?
  - Definitely more than just the radios!
- Describe Cognitive Agent prototype software
  - Cognitive networking framework on the SCaN Testbed
- What does future work look like?



# SCaN Future Architecture

- Moving away from discrete networks
  - Space Network, Near Earth Network, Deep Space Network, ...
- Moving toward unified architecture
  - Seamless service provision, service interfaces, and scheduling for *all* network elements
  - Cross-layer services: raw signals, bitstreams, link-layer frames, packets, UDP, delay-tolerant networking, ...
- Future solar system internet (SSI) as described by CCSDS
  - International, government, and commercial users
    - Should all use networks *responsibly* ...
- Goals for cognitive
  - Reduce user burden
  - Mitigate operational risks due to growing complexity
  - Open-loop communication and navigation services
    - Reduce *need* for direct operator intervention



SCaN

NISN

X-00003-00





# Goals: NASA Intelligent Routing (NITRO) Effort

1

## Reduce operator burden

*Enhance performance on operational efficiency metrics ...*

2

## Improve operator efficiency

*Support scale-up in complexity, diversity, and volume / capacity ...  
... without a corresponding scale-up in human resource allocations*

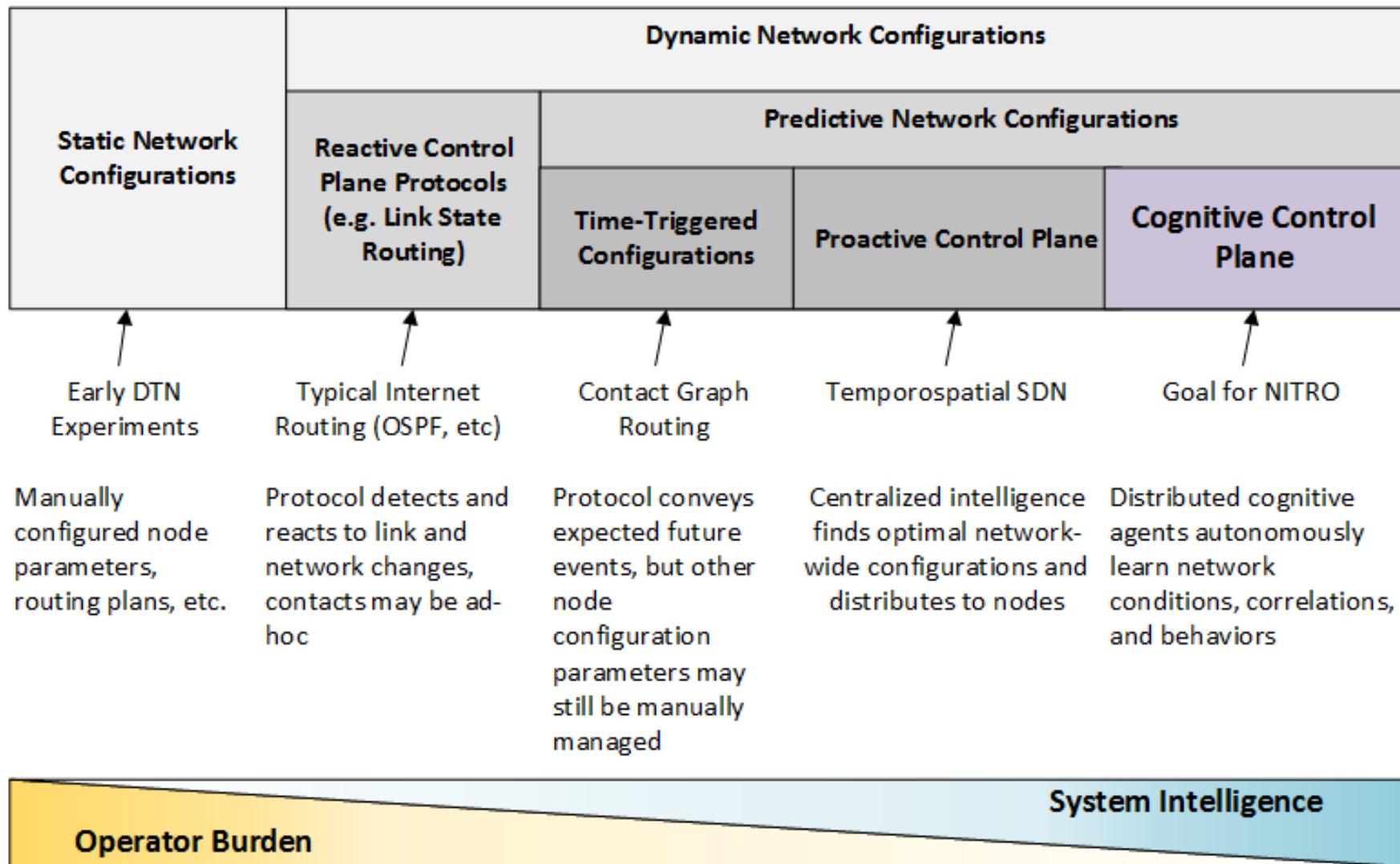
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## Facilitate autonomous operations

*Enable operations where no human can support communications infrastructure (e.g. Mars)*



# Iterative Development



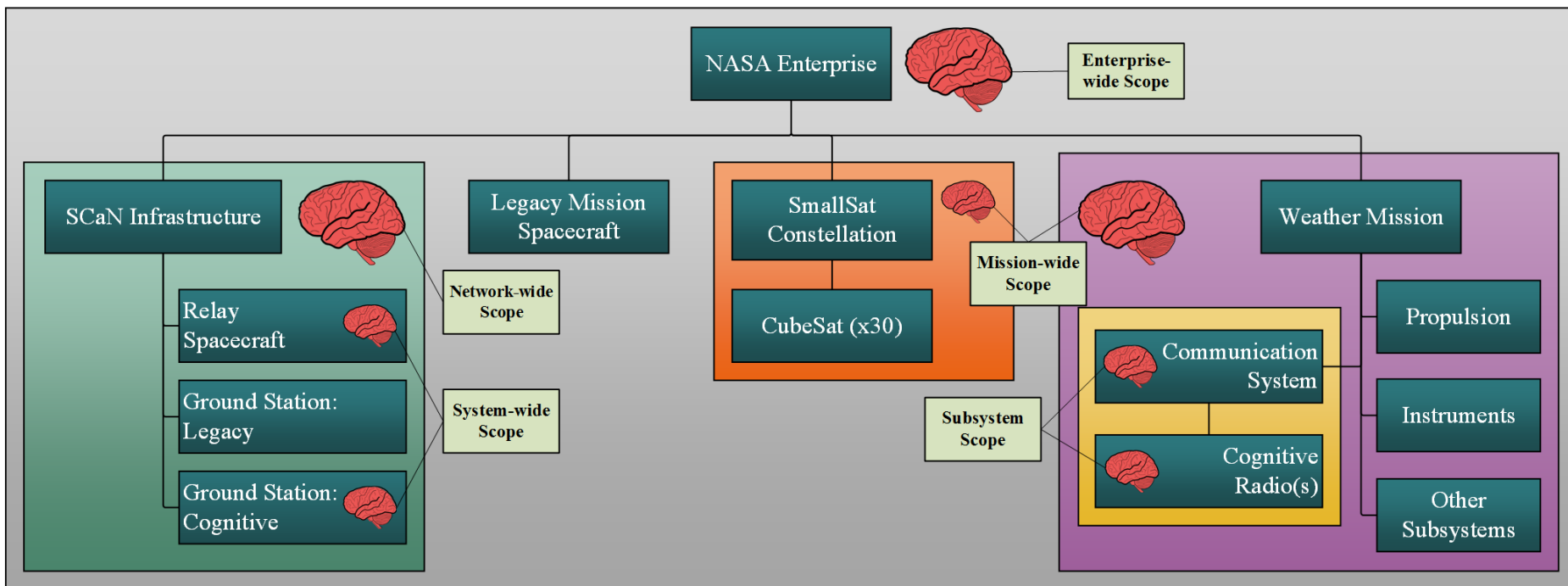


# Toward Cognitive System Engineering

- Not really One True Cognitive to rule them all
  - Instead, things are situationally appropriate
    - Huge number of different AI and ML techniques
      - Neural networks, genetic programming, SVM, and more!
    - Different techniques make sense in different situations
    - Need to blend autonomy and automation ...
      - ... in ways that make sense *for the mission*
  - Many different techniques to achieve cognitive behaviors ...
    - Cognitive offload – perform computation elsewhere
    - Autonomic computing / networking – “self-management”
    - Information-centric networking – emphasize “what”, not “where”
  - ... optimized across many different “domains”
    - “big brain vs. little brain”



# Cognitive Scope

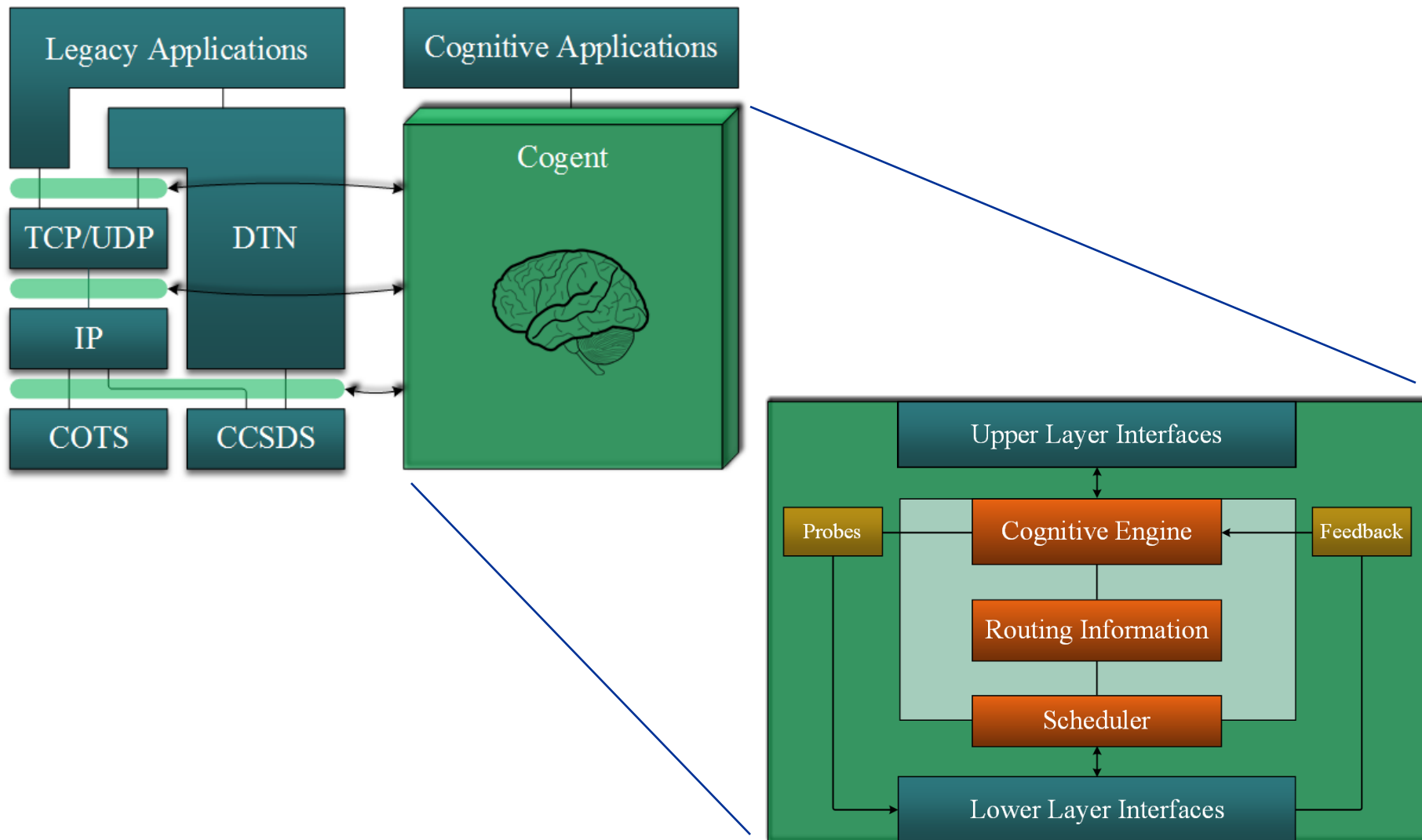




## Prototype Cognitive Agent

- Prototyping intelligent routing software and protocol
  - Built to support present and future flight / ground systems
    - Current on-orbit testing via SCaN Testbed ...
- Empirically determines link characteristics ...
  - ... and makes routing decisions based on goals
    - “minimize latency”, “maximize reliability”, etc.
- Also collects data that can be used for future work ...
  - In order to learn, we need data from which to learn ...
- ... and offers a way to swap cognitive engines
  - Less of a focus on immediate intelligence in *this* agent
  - More of a focus on a good API and an extensible framework
    - Make future experiments easier ...

# Cogent – Construction





## Technology Gaps and Future Work

- Cross-layer signaling
  - Standardization is an important aspect of this ...
- Algorithm development
  - More intelligent approaches to autonomy and management
- Computational offload
  - Incremental upgrade of static hardware resources
- Debugging / management of intelligent systems
  - “You did *WHAT*?! What were you *THINKING*?!”
- Self-knowledge
  - “Generally, I’m not very good at ...”
- Self-design
  - “Wouldn’t it be nice if I could fly?”



## Wrapping Things Up

- Thanks for listening!
- Speaker: Gilbert Clark – [gilbert.j.clark@nasa.gov](mailto:gilbert.j.clark@nasa.gov)
  - Feel free to contact with questions, concerns, etc.
- Questions? Comments? Concerns? Criticisms?